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Observations on the Trap Rocks of the Connewago Hills near Middletown, Dauphin County, and of the Stony Ridge near Carlisle, Cumberland County, Pennsylvania. By the Honorable John B. Gibson.—Read 17th Nov. 1820.

On the Connewago Hills, between Elizabethtown and Middletown, these rocks are found resting on the old red sandstone, which extends from the North River, near New York, to the Rappahannock, near Falmouth in Virginia; and which is here about ten miles broad. They exhibit nothing like stratification, but constitute the summits of the hills; the sandstone preserving a common line of elevation, above which all is either trap rocks, or a grey sandy mould produced from them by decomposition. These rocks are basaltiform greenstone; but they are accompanied by some of the other members of the trap family, such as amygdaloid, wacke, &c. This basalt is of two kinds: The first is of a dark iron grey colour, with a shade of blue, sometimes verging on black; its streak is an ash grey; it is of a compact granular structure, and is chiefly composed of feldspar and augite or hornblende, but as I judge, after an attentive examination with a pretty high magnifying power of the microscope, most probably the latter: it rings when struck; but though extremely hard, gives, with difficulty, a few sparks with steel, and when broken with a hammer, often flies into thin pieces with sharp edges; its fracture is rough,

sometimes inclining to splintery, and sometimes flatly conchoidal; and it is perfectly opake. These rocks have mouldered so much, that their original form cannot be ascertained; the shape in which they now appear undoubtedly being the result of decomposition; but the particular species of which I am now speaking, is usually found in spheroids formed of concentric crusts that fall off in succession as the mass decays. After the first coat is detached, these balls appear perfectly sound; but on being broken, are found to be enveloped with two or three other coats, in a progressive state of preparation for falling off, which decreases towards the centre till the mass becomes thoroughly sound. The outermost crust, by shrinking and chapping, is filled with an infinite number of fissures which cross each other in every direction, and disposed, on being completely detached, to fall into very small pieces, that are soon entirely disintegrated. Within the innermost perceptible layer, the mass, which never contains any foreign body as a nucleus, is equally hard to its centre. In a single instance, I found a quartz pebble, rounded by attrition, embedded in one of these rocks; but they disclose neither organic remains nor vegetable impressions. What shews that the spheroids were not originally formed on a nucleus, or that they did not at first take a figurate form, is, that when, as sometimes happens, they are split by exposure to the weather, each part assumes, in the progress of further decomposition, the form of a distinct sphere, whose crusts take a new point for their common centre, without regard to that by which the general exfoliation before proceeded. In truth, I am of opinion that basalt, or greenstone, is originally always amorphous, and that it takes a determinate form only in a state of decomposition; as is shewn by the columnar basalt of the *Giant's Causeway* in *Ireland;* of the lake of *Bolsonna* in *Italy;* of *Halleberg* and *Hunneberg* in *Sweden;* and other places; which exhibits regular prismatic forms only when it has long been exposed to the action of the atmosphere; for whenever a part of the surface has been removed, the interior

has exhibited only the incipient appearance of regular forms; and doubtless every rock of the kind would, if penetrated to a sufficient depth, be found to be a solid mass. Humboldt, it is true, in his account of the breaking out of the volcano of Jorullo in the intendancy of Valladolid in Mexico, says that strata of clay, enveloping balls of decomposed basalt *in concentric layers*, were thrown out: but these, although actually ejected in a figurate shape, it clearly appears, were not then recently formed, but were the product of anterior convulsions, and had long lain in the ground in a state of decay. But the crystalline form of basalt has, at all events, received an importance with respect to the question of origin, which it by no means deserves: for although it is conceded that columnar and other figurate forms exist in rocks of aqueous origin, it has been proved, by the well known experiments of Mr. Gregory Watt, that both the columnar and globular structure *may* be produced by the slow refrigeration of a mass of melted basalt; and lava has been found in Filicuda, one of the Lepari islands, in perfect columns, and imperfectly columnar in the island of Ponga.

The second species is soft and friable throughout, usually amorphous, and of every intermediate shade between a dark and an ash grey; but most frequently of the latter. It is of a coarse open structure, and so soft, that some specimens may be crumbled between the fingers. It is not incrustated; but the whole mass, when disintegrated, falls into a coarse sand with a rather slight intermixture of clay. It is not very abundant, and is used with advantage in giving a smooth surface to the turnpike road which leads from Lancaster to Harrisburg; the body of which is constructed of the harder species, which is also sometimes amorphous.

Both kinds, when exposed to constant moisture, are covered with a reddish brown, whose depth of colour is in proportion to their hardness: hence the harder masses contain more iron. These rocks correspond, in almost every particular, with the descriptions we have of the incrustated

basalts of Europe, except that they, as well as those of the Stony Ridge, of which I shall presently speak, are decomposed much more readily below the surface of the ground than when subjected to the action of the weather. As oxygen is the chief, perhaps the only agent in dissolving them, their iron must be in the lowest state of oxidation; and their decomposition is therefore accelerated by a position, which by constantly exposing them to moisture, quickens the change of their iron in its passage into a peroxide. But it is by no means certain that their decomposition is effected exclusively by means of the iron they contain; for the feldspar which is one of their constituents, may, by being decomposed, also contribute to effect a decomposition of the whole rock. When the ground is penetrated where the rocks are most abundant on the surface, nothing is usually found but a yellowish sand mixed with a portion of aluminous clay, and forming a cold meagre mould of little value for purposes of husbandry. Hence it is a practice with the owners of the land, who have of late begun to clear some parts of it, to bury the rocks where they lie; and it succeeds very well.

The question respecting the origin of trap rocks has engaged the attention of the most celebrated geologists, and it would therefore be presumptuous in a sciolist to attempt to discuss it further than as it is directly involved in the subject on which he professes to treat. I may however be permitted to remark, that there is nothing in the position of the trap of the Connewago Hills, to indicate its being igni-genous. The common answer to arguments drawn from the absence of all the characteristics of a volcanic mountain, to wit that the basalt was formed on the bosom of the mountain itself, and afterwards denuded by the removal of the superincumbent mass, cannot be admitted here; because in that case we ought not to expect to find it resting on even the oldest of the secondary rocks. That it may have been deposited on the sandstone by a volcano, before the present continent was elevated above the level of the sea, would be

a more plausible supposition; but it would be altogether gratuitous. Perhaps the Plutonists and Neptunists have both been wrong in refusing to admit of exceptions to their respective theories; and particularly with respect to the formation of trap rocks, which probably ought not to be exclusively referred to the agency of either fire or water.

But the Stony Ridge near Carlisle presents appearances more decisively volcanic. In structure, the trap of which its rocks are composed, differs but little from that of the Connewago Hills, except that it is somewhat harder, of a finer granulation, and a darker colour; but it is decomposed in the same way, is covered by the same ferruginous coat, and would, on being analysed, probably exhibit but little difference of result in the relative quantity of its constituent parts. The rocks differ more in size and shape, those of the Stony Ridge being smaller, and very rarely globular. They present no columnar appearance, but at the Carlisle Ironworks, where the ridge has been penetrated, I have observed something like arrangement in their position, although I cannot say they were of a crystalline form. It is however not so much in the structure of its rocks, as in the position of the ridge itself, that the evidence of its igneous origin is found. The valley is here about twelve miles wide. Its bottom is formed of an extremely compact transition limestone, which, dipping at an angle of from thirty to forty degrees, presents the broken edges of its strata, and forms a pretty uneven surface. Between the Conodoquinnet creek and the North, or as it is here called, the Blue Mountain, the limestone is covered by schistus, and between the Yellow Breeches creek and the South Mountain by gravel. This limestone formation, though it occupies the valley in nearly its whole extent, certainly for a distance of five hundred miles, is not exclusively confined to it, but appears at the same level to the south of the South Mountain, and forms the soil of Frederick county in Maryland, of a great part of York, and of the whole of Lancaster counties in Pennsylvania. The North and South Mountains are composed of quartzose masses, of grey

wacke, and of a puddingstone, which sometimes contains marine shells. The ridge in question then, four miles east of Carlisle and distant twenty-four miles from the basalt of the Connewago Hills, stretches, by a course somewhat meandrous, from the foot of the North Mountain, across the valley, till it arrives at within two miles of the South Mountain, where it terminates abruptly, filling the cavities of the bottom of the valley, and forming an overlying unconformable mass of the newest flœtz trap of Werner, so unlike every other rock in the neighbourhood, as to arrest the attention of the inhabitants. Its base is about three hundred yards broad, and its height from twenty to thirty, its summit being nearly a dead line. The transverse direction and want of conformity to the stratification of the limestone, as well as the isolated situation of the ridge, give it a strong appearance of having originally been a stream of lava: to convince one of which, nothing is wanting but an extinguished crater in the North Mountain. But I by no means consider its absence a decisive objection; for rocks undoubtedly volcanic are found, where all vestiges of a crater have long been obliterated. But in the present instance I see no necessity for one having ever existed. If there is any position in geology thoroughly established, it is that the crust of the earth has undergone a series of great and sudden revolutions, which have buried all the countries that were before inhabited. From the animal and marine organic remains alternately imbedded in the different strata of transition and secondary rocks, it is demonstrated by M. Cuvier, that every part of the surface of the globe has, by subsidence or upheaving, alternately been the bottom of the sea and dry land. To what cause but subterraneous fire can effects such as these be attributed? It is idle to talk of the motion of the sea from east to west, of the action of the tides, or deposits of sediment: unless we return to the exploded notion of the earth having suffered violence from the oblique stroke of a comet, we shall be unable to imagine any possible force

applied *ab extra*, that is competent to produce them. Electricity must also be rejected; for the whole quantity of that fluid which exists in the universe would be insufficient to charge the earth so highly, as to produce by its discharge the immersion of continents and the elevation of the bottom of the sea above the level of its surface. Although there are non-conducting bodies in the earth; yet as water, which at every temperature between ice and vapour is an excellent conductor, pervades every part of it, it would be impossible to confine the fluid to any particular place, and the whole globe would have to be charged. But the clouds and every thing coming into contact with the surface, would abstract at least a portion of it. Every one who has experienced the difficulty of confining this fluid by the best insulation of glass or resins, will readily acknowledge this. Then to collect a sufficient quantity of fluid, would require over the whole surface of the earth an uninterrupted continuance of a state of things favourable to such a result for a longer period than can, in the nature of things, be expected ever to have taken place. Besides, only dry earth is an electric *per se*; for when it is mixed with water, in which state only it is a constituent part of the globe, its power of being electrically excited is proportionally decreased; so that the solid parts of the globe would, independently of the effects produced on them by the contact of seas and rivers, be capable of excitement in a degree so very low, as to render them inadequate under any circumstances to collect the quantity of fluid required: but when to this is added the contact of lakes, rivers, and seas, we shall find that the globe is altogether incapable of being electrically excited. In Werner's theory, the alternate submersion and emergence of the different portions of the earth's surface is not a postulate, and of course he does not pretend to account for it. His notion that the waters originally covered the whole surface, and that they gradually, and at length finally, retired into caverns at the earth's centre, left empty at the creation for their reception, having first deposited the strata in the broken

state, and inclined positions in which we now find them, is hostile to every thing like fair induction from facts and propositions conceded on all hands. Then to assign an adequate cause for the effects discoverable in the disjointed and scattered condition of the earth's crust, we are driven by necessity to have recourse to the theory of Dr. Hutton,* which, although we may not choose to adopt it in its full extent, alone affords a rational solution of the difficulties that embarrass the subject. While I acknowledge that his theory of the consolidation of the strata by means of heat at the bottom of the sea, appears to be altogether unnecessary and beset with insuperable difficulties, I am compelled by the want of any other adequate agent to assent to his doctrine that the changes between oceans and continents are due to the expansive power of heat from below. Earthquakes are doubtless the more languid efforts of the same power; and when during these, we behold the surface of the earth tossing like a sea, while mountains are raised or districts of country swallowed up, we may judge of what it is capable of effecting, when roused into full activity. In earthquakes as well as volcanoes, electricity acts an efficient but subordinate part; for during an eruption, vivid flashes of lightning issue from the clouds of pumice and ashes sent up, and shocks of earthquakes are frequent and violent. Mountains are nothing but dislocated portions of the earth's crust, and must therefore owe their formation to the same general cause that effected the other parts of the grand revolution. Else how could granite, the lowest of the known formations,

* The changes that have taken place on the earth's surface, were, it seems, at a very early period ascribed by Xanthus to earthquakes and subterraneous fires, which, at the deluge, elevated some portions of the bed of the sea, as well as depressed others, and produced the inequalities of the solid parts of the globe. This opinion was afterwards, in 1692, in substance adopted by an English geologist of the name of Ray; and also in 1740 by an Italian called Lazaro Moro. Their writings may have suggested to Dr. Hutton a distinguishing feature of his theory: but none of them appear to have suspected what he has, I think, established, a succession of continents which he calls a succession of worlds.

be found constituting the summits of the highest peaks? Every appearance connected with the structure of Alpine mountains irresistibly tends to one conclusion, that they have been pushed up through the superincumbent strata, whose *debris* are found resting at their bases, or on their flanks. In truth there is such an apparent mutual and intimate connexion between those mountainous elevations of the crust, and volcanoes and earthquakes, that it is impossible to regard them as distinct phenomena. Earthquakes are more frequent and violent in volcanic countries, and the mountains become more gigantic as we approach the torrid zone, the peculiar seat of volcanic action; and in Europe, let me add, earthquakes are more frequent in the vicinity of trap formations than elsewhere. From all this there is reason to conclude, that there are long ranges of subterraneous fire at an immense depth, and that volcanoes are merely the vents through which, as a safety valve, are discharged the elastic vapour and other substances, which, when confined, are the cause of earthquakes, and of the upheaving of mountains or even continents.

But to return from this digression. Would it be surprising, if, during a convulsion capable of producing results so tremendous as the breaking up of the earth's crust, a stream of lava should escape through a lateral opening at the base of a mountain newly formed, or that had been thrown up by a previous effort of the same power? A crater is formed by the gradual accumulation of pumice and ashes ejected by an established volcano; but I see no reason to doubt that a single eruption might take place in the manner suggested, which would be sufficient to account for the absence of all traces of a crater and the want of that conical shape so observable in the mountains of volcanic countries. But that conic shape so decisively volcanic, furnishes no argument that the power which caused it might not, by a different mode of operation, produce those long uniform ridges which constitute the chains of mountains in North America. Humboldt describes Antisan and Pichinca, two volcanoes in the province of

Quito, as each having no cone at all; but as being in one direction a lengthened ridge, sometimes smooth and sometimes rough, with pointed rocks. In Europe and Asia, no active volcano is situated in a chain of mountains; but in America, in a range of from four to five thousand miles north and south, the most stupendous volcanoes form a part of the Cordilleras; and this range of subterraneous fire is crossed between the eighteenth and nineteenth degrees of north latitude, by another extending from the Gulf of Mexico to the Pacific Ocean. Humboldt considers the whole province of Quito as a volcanic abyss covered with a crust whose craters are different vents to one continuous mass of fire. When we consider the influence which distant volcanoes are known to have on each other, we cannot doubt the existence of a range of subterraneous fire serving to connect them; and when we see a line of volcanoes coinciding with the course of the longest chain of mountains in the world, we are forced to believe that, as the mountains could not have produced the volcanoes, the volcanoes must have had some concern in producing the mountains. It is not an extravagant theory, then, that all chains of mountains have been produced by volcanic fire, acting either generally and raising above the surface of the sea the immense edges of the earth's crust as the original framework of a continent, or in veins at an immense depth below the surface of land already elevated, without, except in a few instances, breaking through the crust acted on; and that masses of overlying trap may be volcanic products, emitted, in either case, through accidental openings, where no remains of a crater appear. I know not whether this idea is in any respect new; but I acknowledge that many of the arguments I have employed are not new; but as they were those which naturally and powerfully resulted from established facts, I thought myself justified in appropriating them to the support of my hypothesis.

It may be objected, that from the vicinity of the Connewago Hills to the Stony Ridge, it ought to be presumed that the trap of both places had a common origin. But to those

who require that a theory should explain and reconcile all the phenomena connected with its subject, it may be answered, that it is conceded by many advocates of the Huttonian system, that some basaltic rocks may have been formed in the humid way from eruptions of mud such as issue from some volcanoes in South America: not those that are properly called *mud* volcanoes, which are destitute of heat, and whose eruptions are produced by a fermentation in which common salt is supposed to be concerned; but actual fire volcanoes into which water has found its way. In this manner a different origin may consistently be attributed to the rocks of both places. But I do not say that the trap of the Connewago Hills is not a volcanic product, but only that it exhibits no *peculiar indicia* of igneous origin.

In conclusion, however, it must be acknowledged that the footsteps of the agent employed to work those grand changes of which we every where see such convincing proofs, are so intricate and confused, that we never can expect with absolute certainty to trace them home. The Huttonian system, though open in some of its parts to strong objection, affords the most rational solution of the most important phenomena of the earth, and must eventually gain ground. Connected with this subject there are few facts so devoid of interest as to be unworthy of being communicated; and the author of these observations therefore trusts he will not be considered a trespasser on public attention, by having given them publicity.